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Optimization of investment management in Warsaw stock market

Abstract: Application of simple prescriptions of technical analysis on the Warsaw Exchange Market (GPW) has been analyzed using several stocks belonging to WIG20 group as examples. Only long positions have been considered. Three well-known technical-analysis indicators of the market have been investigated: the Donchian channels, the Relative Strength Index, and Moving Average Convergence-Divergence indicator. Optimal values of parameters of those indicators have been found by „brute force” evaluation of (linear) returns. It has been found that trading based on both Donchian channels and Relative Strength Index easily outperform the „buy and hold” strategy if supplied with optimal values of parameters. However, those optimal values are by now means universal in the sense that they depend on particular stocks, and are functions of time. The optimal management of capital in the stock market strongly depends on the time perspective of trading. Finally, it has been argued that the criticism of technical analysis which is often delivered by academic quantitative financial science is unjustified as based of false premises.

Key-words: Warsaw Exchange Markets, technical analysis, indicators of the market.

Introduction

The problem of optimization of management of investments in financial markets belongs, needless to say, to those of paramount importance for quantitative financial sciences. Among the methods which have long been applied to increase profitability of investments, one can mention, among the most popular, those associated with the terms „fundamental analysis” and „technical analysis”. Both are popular among the traders, and both have attracted interest of researchers. In particular, the role of technical analysis in trading in the stock market has been highly controversial. On one hand, it has very often been declared as a kind „pseudoscience”, which, because of the incorrectness of its most important principles, cannot and does not lead to any sustainable increase of returns above the market level [Malkiel 1981, Fama and Blume 1966]. On the other hand, there is also a tendency among many practicing traders to appear technical analysis blindly, without any serious knowledge about the market dynamics. The second tendency is a matter which is beyond the scope of this work. Below we shall, however, address the first one.

One may first of all observe that any long-standing successful trading with the help of technical analysis could, in principle, be considered a strong argument against its adversaries. But that assertion would be too hasty and simplistic. Indeed, the statements of great efficiency of technical analysis usually come from the people whose claims cannot be verified because their behavior at the stock market cannot be traced in full detail, and it is not clear whether their declarations about their usage of technical analysis tools are reliable even though they may be sincere. More importantly, technical analysis has been criticized for its failure to recognize that the markets, or at least the mature markets, are close to being efficient, and their dynamics closely resembles fully random walks without any significant correlations. In short, one cannot make any predictions.

Against such statement we would like to provide two arguments. Firstly, the statement about the random-walk character of the dynamics of stock market prices have long been falsified [please see, e.g. Lo and McKinley 1988]. Secondly, the technical analysis has inherently *local* character in both time and „space”. Indeed, the time horizon of many traders does not exceeds several years, or in the best case, several decades. What is more, there is almost not a single trader who would „test” *all* the assets on the stock market. No more than several tens of them are involved. Therefore, investigations of the value of technical analysis which attempt to take into account as huge amount of data as possible using heave apparatus of statistics completely miss the point even though in several case they seem, perhaps somewhat surprisingly, vindicate the technical analysis [please see, e.g. Brock, Lakonishok and LeBaron 1992; Allen and Karjalainen 1999; Lo, Mamayski and Wang 2000]. As all other fields of

human activity, the technical analysis should be considered and its value tested as it is really applied, and not as academic researchers imagine it should.

In addition, it is of critical importance that, according to surveys, technical analysis if used by the fund managers, both small and large ones. This means that the technical analysis actually *does* influence the very dynamics of the market that is a subject of the science of financial market, and as such, must be considered seriously. We would like to mention here that we have read many times complaints of small-scale scale traders who say that the prize of such or that stock behaves as if some big players just wanted the technical-analysis indicators to work or to remain valid. And should science take into account hearsay? Yes, when hearsay does drive the events which are under investigations. Such a process does indeed happen in financial markets.

In this contribution we provide results of our investigations regarding the applicability of three simple indicators of technical analysis: the Donchian channels (DC), Relative Strength Index (RSI) and Moving Average Convergence-Divergence (MACD), the latter in two variants which differ in how the buy and sell signals are defined.

They have been chosen for two reasons: firstly, they are reasonably popular among traders. Secondly, the trading rules are unambiguous and straightforward. We hasten to state that our approach is also an idealization. It happens very rarely that a trader uses just one of the indicators in his or her investments. However, we feel that some degree of idealization has been necessary at this stage.

Twenty stocks of the Warsaw Exchange Market has been chosen to illustrate the results of optimization. . Their advantage is that while not all of them belong to the most popular trading stocks, they all form the group of Polish „blue chips”, i.e. the WIG20 group.

The main body of our work is organized as follows. In Section 2 we provide a short description of the three indicators considered here. Section 3 consists of our qualitative results regarding the optimized parameters and their dependence of time and stock. Section 4 contains the discussion and some concluding remarks.

Donchian Channels, Relative Strength Index and Moving Average Convergence-Divergence

The Donchian channels have been introduced by Richard Donchian in the sixties. According to Farlex Financial Dictionary [Farlex, 2012], Donchian Channels „consist of two moving averages stating the highest high [i.e. maximum, JOW] and the lowest low [i.e. Minimum, JOW] for a security over the desired time period. The highest high and the lowest low are each replaced as the previous ones move out of the current time period. According to this device, a buy

signal occurs if the price of a security closes above the current highest high and a sell signal occurs if it closes below the lowest low.” The space between the moving averages is called the „channel”. Let us notice here that both the indicator itself and the trading signals are both extremely simple. Also, let us stress the signals appear to be counterintuitive: one has to buy when the prices are „high” and sell when they are „low”. The rationale behind is that the Donchian channels are meant to be a trend-following devices: when the price crosses the highest maximum in a certain time period from below, this may be a beginning of an upward trend; when the price crosses the lowest minimum (in a time period) from above, this may signal the downward trend. In addition, the lowest low of n periods can serve as a stop loss for the trader.

The Donchian channel indicator has three parameters: the period I of which the highest maximum is calculated, the period J of which the lowest minimum is calculated, and M – the time (in market sessions) after which the position is unconditionally exited – that is, the securities are all sold.

Donchian himself recommended to take $I = 20$, $J = 10$, $M = 80$, and those values are usually considered standard (they will be called thus in the following).

The Relative Strength Index [Murphy 1999, Kaufman 2013] attempts to give quantitative meaning to the intuitive notion of the „strength” of a stock. The security is „strong” if its price tends to grow in period of time, and it is „weak” if its price tends to decrease in the same period of time. Quantification of that idea is performed via the following procedure:

1. For each trading day n in a given period of M days, one defines U_n as $C_n - C_{n-1}$ if $C_n > C_{n-1}$ and zero otherwise. Similarly, one defines V_n as $C_{n-1} - C_n$ if $C_n < C_{n-1}$ and zero otherwise. C_n means here the closing price on the day n .
2. One calculates exponential moving averages $E_{U,M}$ and $E_{V,M}$ in considered period for both U_n and V_n .
3. The relative strength factor RS is then calculated as the ratio: $E_{U,N} / E_{V,N}$.
4. Finally, the strength factor is converted so that it takes values from 0 to 100. $RSI = 100 (1 - 1/(1 + RS))$.

The latter quantity is called the relative strength index. Taking the value 30 or less by RSI is usually considered to be buy signal, while taking the value 70 or above is considered to be a sell signal. Other pair of values, like (20, 80) can also be found in the trading literature. In our simulations, we optimized three parameters of RSI: the value which gives the buy signal I , the values which provides the sell signal J , and the period M over which the exponential moving averages are computed. Thus, $RSI = RSI(I, J, M)$. The case of $I = 30$, $J = 70$ and $M = 14$ will be called *standard*.

Finally, the MACD indicator is usually defined as follows [Murphy 1999, Kaufman 2013]: Let $EMA(n)$ denotes the exponential moving average of last n closing prices with the weighting factor $\alpha = 1 - 2 / (n + 1)$. Then the MACD

indicator is defined as $EMA(EMA(I) - EMA(J), M)$. Two elementary ways of using MACD can be found in practice of trading: (1) Crossing of MACD the value 0 from below is a buy signal (entering long position) while crossing that value from above is a sell signal – in the following, we shall call the trading based on the above rule simply as “MACD trading”; (2) Passing of MACD indicator through a lower-than-zero (local) minimum is a buy signal, while its passing through a larger-than-zero (local) maximum is a sell signal – we shall call the trading method based on the second rule as “modified MACD trading”.

Needless to say, the triples (I, J, M) have completely different meaning in the above three indicators.

Results of simulations

We have performed simulations for the securities traded in the Warsaw Exchange Market (GWP) belonging to the groups which has been used to calculate WIG20 index. These are: ASSECOPOL, BOGDANKA, BZWBK, EUROCASH, GTC, HANDLOWY, JSW, KERNEL, KGHM, LOTOS, MBANK, PEKAO, PGE, PGNIG, PKNORLEN, PKOBP, PZU, SYNTHOS, TAURONPE, and TPSA. Optimal values of (I, J, M) in the case of the Donchian channel, RSI indicator as well as two variants of MACD-based trading have been found by straightforward evaluation of returns. The values I and J in the case of RSI are actually real (i.e. continuous, not discrete). However, for simplicity of the optimization procedure they have been considered as integers, as is the common practice in the technical analysis. Time periods of the optimization have been equal to the total times of trading of a given security in GPW. It has been assumed that the cash in hands of the simulated trader has initially been equal to 10,000 PLN. The costs of every cell or buy would be set equal to 0.38% of the transaction value (this is a recent standard in Polish broker houses).

The results are contained in the following tables:

1. ASSECOPOL (3908 trading sessions)

Table 1. Optimal values of parameters as well as final values of assets for Assecopol stocks

Optimal value		Trading method			
		Donchian channels	RSI	MACD	MACD modified
	I	35	8	39	6
	J	5	92	74	7
	M	62	8	36	5
	Final value of assets	114749.01	62565.64	39138.68	34451.11

Source: own calculations.

2. BOGDANKA (1136 trading sessions)

Table 2. The same as in Table 1 but for the Bogdanka stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	5	29	11	22
	J	26	77	56	74
	M	77	10	5	20
	Final value of assets	27831.50	27227.62	24781.31	18293.17

Source: own calculations.

3. BZWBK (5017 trading session)

Table 3. Optimal values of parameters as well as final values of assets for BZWBK stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	3	39	10	14
	J	22	97	18	44
	M	50	6	7	2
	Final value of assets	762820.03	852610.89	136253.21	1002823.20

Source: own calculations.

4. EUROCASH (2230 trading sessions)

Table 4. Optimal values of parameters as well as final values of assets for EUROCASH stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	7	22	19	3
	J	31	24	21	35
	M	65	75	18	62
	Final value of assets	104984.15	364294.33	36832.79	52327.94

Source: own calculations.

5. GTC (2425 trading sessions)

Table 5. Optimal values of parameters as well as final values of assets for GTC stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	12	14	34	30
	J	15	64	96	94
	M	79	6	32	2
	Final value of assets	26751.93	25554.88	20970.78	10645.59

Source: own calculations.

6. HANDLOWY (4136 trading sessions)

Table 6. Optimal values of parameters as well as final values of assets for HANDLOWY stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	20	25	34	3
	J	23	81	65	35
	M	53	19	9	62
	Final value of assets	92239.70	89981.12	38446.39	55503.22

Source: own calculations.

7. JSW (623 trading sessions)

Table 7. Optimal values of parameters as well as final values of assets for JSW stocks

Trading method					
Optimal value		Donchian channels	RSI	MACD	MACD modified
	I	23	22	3	3
	J	25	24	35	35
	M	79	75	62	62
	Final value of assets	11910.00	15216.70	9915.87	9172.28

Source: own calculations.

8. KERNEL (1528 trading sessions)

Table 8. Optimal values of parameters as well as final values of assets for KERNEL stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	3	4	9	3
	J	38	99	74	4
	M	73	5	6	2
	Final value of assets	27544.51	22839.28	35856.60	23703.34

Source: own calculations.

9. KGHM (4130 trading sessions)

Table 9. Optimal values of parameters as well as final values of assets for KGHM stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	18	10	39	20
	J	20	95	62	35
	M	63	7	11	8
	Final value of assets	186221.43	397272.15	194471.18	15829.92

Source: own calculations.

10. LOTOS (2149 trading sessions)

Table 10. Optimal values of parameters as well as final values of assets for LOTOS stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	18	22	3	3
	J	15	24	35	35
	M	59	75	62	62
	Final value of assets	49481.33	81626.27	22047.01	29191.29

Source: own calculations.

11. MBANK (5120 trading sessions)

Table 11. Optimal values of parameters as well as final values of assets for MBANK stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	5	22	3	3
	J	28	24	35	35
	M	41	75	62	62
	Final value of assets	2565292.43	1998540.30	2325744.08	150331.19

Source: own calculations.

12. PEKAO (3891 trading sessions)

Table 12. Optimal values of parameters as well as final values of assets for PEKAO stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	6	20	39	28
	J	40	80	78	98
	M	50	12	32	25
	Final value of assets	35905.75	296552.12	19569.77	23496.80

Source: own calculations.

13. PGE (1040 trading sessions)

Table 13. Optimal values of parameters as well as final values of assets for PGE stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	5	19	30	39
	J	35	81	40	73
	M	57	2	28	38
	Final value of assets	11187.84	16559.23	11682.71	10869.26

Source: own calculations.

14. PGNIG (2074 trading sessions)

Table 14. Optimal values of parameters as well as final values of assets for PGNIG stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	7	14	12	32
	J	38	90	23	34
	M	76	3	10	12
	Final value of assets	11328.94	42090.02	11690.10	15378.79

Source: own calculations.

15. PKNORLEN (3535 trading sessions)

Table 15. Optimal values of parameters as well as final values of assets for PKNORLEN stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	26	37	29	27
	J	16	71	30	99
	M	53	14	26	2
	Final value of assets	17285.73	51896.76	7527.94	18989.61

Source: own calculations.

16. PKOBP (2294 trading sessions)

Table 16. Optimal values of parameters as well as final values of assets for PKOBP stocks

Optimal value		Trading method			
		Donchian channels	RSI	MACD	MACD modified
	I	16	33	37	38
	J	32	75	93	92
	M	73	21	21	36
	Final value of assets	30307.10	41116.70	19303.52	21680.69

Source: own calculations.

17. PZU (914 trading sessions)

Table 17. Optimal values of parameters as well as final values of assets for PZU stocks

Optimal value		Trading method			
		Donchian channels	RSI	MACD	MACD modified
	I	11	28	32	3
	J	26	77	72	4
	M	51	7	21	2
	Final value of assets	14580.80	20089.05	13295.70	11613.98

Source: own calculations.

18. SYNTHOS (2267 trading sessions)

Table 18. Optimal values of parameters as well as final values of assets for SYNTHOS stocks

Optimal value		Trading method			
		Donchian channels	RSI	MACD	MACD modified
	I	39	22	3	3
	J	32	24	35	35
	M	80	75	62	62
	Final value of assets	197823.08	216143.30	120661.35	97890.31

Source: own calculations.

19. TAURONPE (880 sessions)

Table 19. Optimal values of parameters as well as final values of assets for TAURONPE stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	24	25	11	3
	J	40	73	26	4
	M	80	12	8	2
	Final value of assets	13558.21	18523.56	11880.63	14115.00

Source: own calculations.

20. TPSA (3791 trading sessions)

Table 20. Optimal values of parameters as well as final values of assets for TPSA stocks

Optimal value	Trading method				
		Donchian channels	RSI	MACD	MACD modified
	I	32	20	38	37
	J	38	83	86	54
	M	49	8	32	9
	Final value of assets	28316.83	33474.49	10702.80	6714.83

Source: own calculations.

All simulations leading to the above results has been performed using a home-made program written in Python. As the numerics has been rather simple, no special numerical packages except of the module Numpy have been used.

Discussion

Probably the most remarkable feature of the above data is that the optimal values of both DC and RSI parameters are completely different from the standard ones. Only the parameter *M* of the Donchian channel strategy (which gives the number of trading days after which the trader receives a signal of unconditional exit) in most cases comes close to the standard value of 80. What is also striking and strongly counterintuitive is that in most case the value of *J* is larger than that of *I*. This is counterintuitive because during the downward trends the prices decrease much faster than they increase during the upward trend.

As for the trading based on the Relative Value Index, let us first of all observe that the optimal number M is in most cases smaller than standard 14. It appears that in our stocks the optimal value of M favors strongly a short-time, even swing-like trading if indeed the latter is to be based on RSI. Another remarkable feature of the data provided in Tables 1-20 is that the maximal returns, are in several cases larger if DC-based strategy is used when compared to RSI-based strategies. This is again quite counterintuitive because DC-based trading appears to go exactly against the well-known saying „buy cheap and sell expensive”. Of course, this is just an appearance: trading using Donchian channels is an excellent method to follow a trend if a strong upward trend appears.

In addition, we have observed that the optimized strategies crushingly outperform both their standard counterparts and „buy and hold” strategy. Sometimes the difference may be of two orders of magnitude. What is particularly interesting is the very poor performance of the standard RSI trading system. For instance, in the ASSECOPOL case it can lead to almost catastrophic losses if unsupported by any other trading rule (3043.99 PLN made of initial 10000.00 PLN). One reason for that is the fact that RSI-based system does not possess any stop loss on its own, unlike DC-based system. On the other hand, optimal usage of RSI strategy can also lead to spectacular profits, as can also be seen from the Tables above. In general, both DC-based and RSI-based trading system bring better results than simple applications of MACD investigated here.

Let us stress that trading strategies considered make only very elementary attempts to really predict the future market behavior are made. DC-based strategy attempts to guess the appearance of upward and downward trends. RSI attempts to guess closeness to the upward and downward turning points.

The latter statement is also true about MACD-based methods. But these strategies as well as, in fact, all other technical-analysis systems, do not make any quantitative assumptions about possible correlations.

One might argue, however, that our findings are devastating for technical analysis. Indeed the standard recommendations regarding DC and RSI parameters appeared to be disproved, or at least shown to be very far from universal. And, needless to say, the optimal values of parameters can only be known *a posteriori*. The following questions naturally appear: can one obtain large (that is, far exceeding those provided by „buy and hold” strategy) returns if one reevaluates the optimal values of, say DC or RSI after some period of time so that the trading system is being updated with a particular frequency? Secondly, do there exist any reasonably stable islands of suboptimal values of parameters? Thirdly, can one find optimal or suboptimal islands of parameters in a portfolio of securities rather than single stocks? Work is in progress to find answers to the above questions which will be reported in a future publication.

Finally, let us note that the time evolution of stock market prices can be, and is, a subject of econometric and econophysical analyses. This matter, however, is obviously beyond the scope of the present paper.

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